United States Patent [19]

Ward, Jr.

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[54] **BOX BLANK FOLDING APPARATUS**

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[73] Assignee: **The Ward Machinery Company**, Cockeysville, Md.

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[51] **Int. Cl.**[3] **B31B 1/42**; B31B 1/54

[52] **U.S. Cl.** **493/295**; 493/179; 493/437

[58] **Field of Search** ..... 93/52, 49 R, 48, 45; 53/374; 493/295, 178–182, 437, 126, 142, 151

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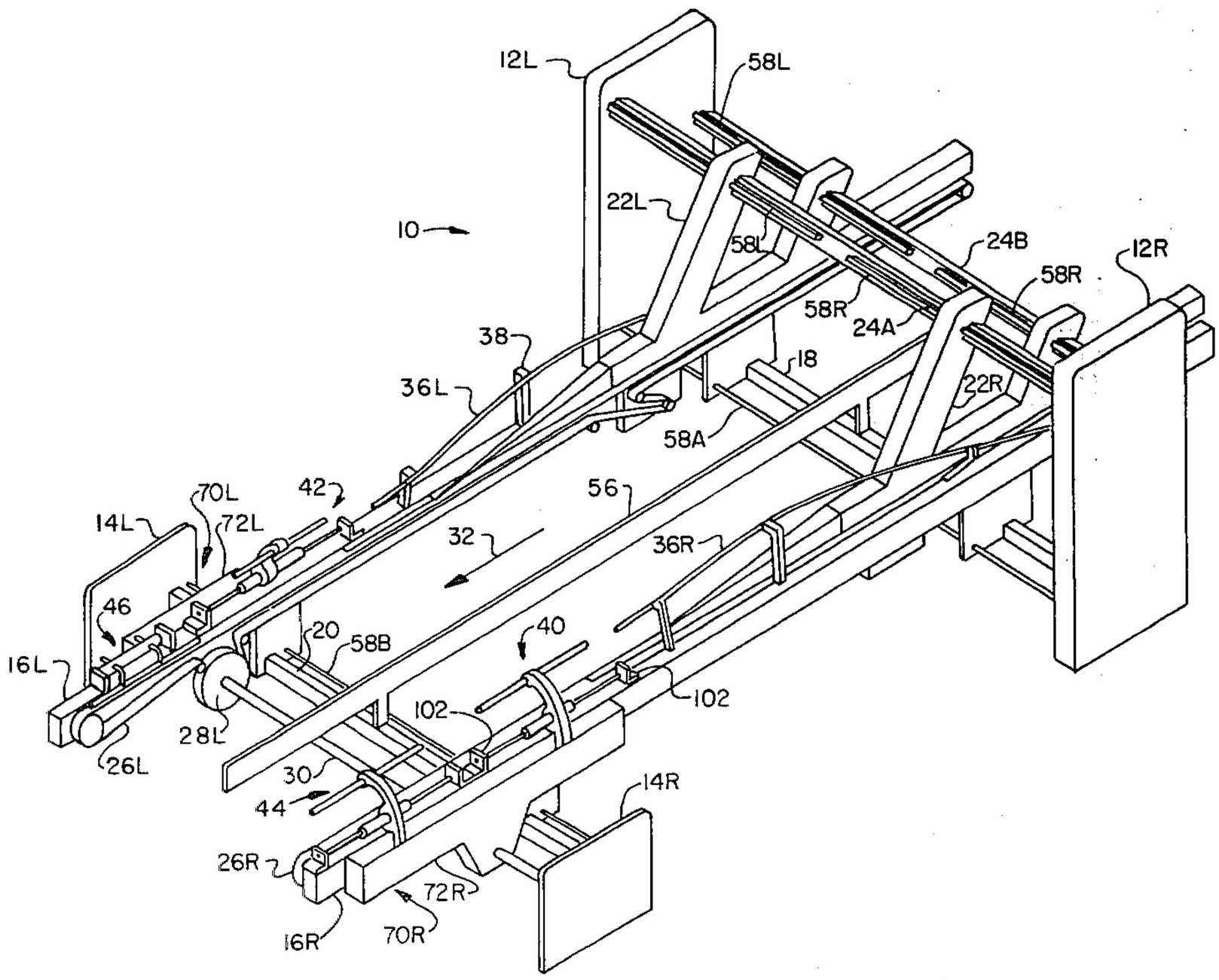
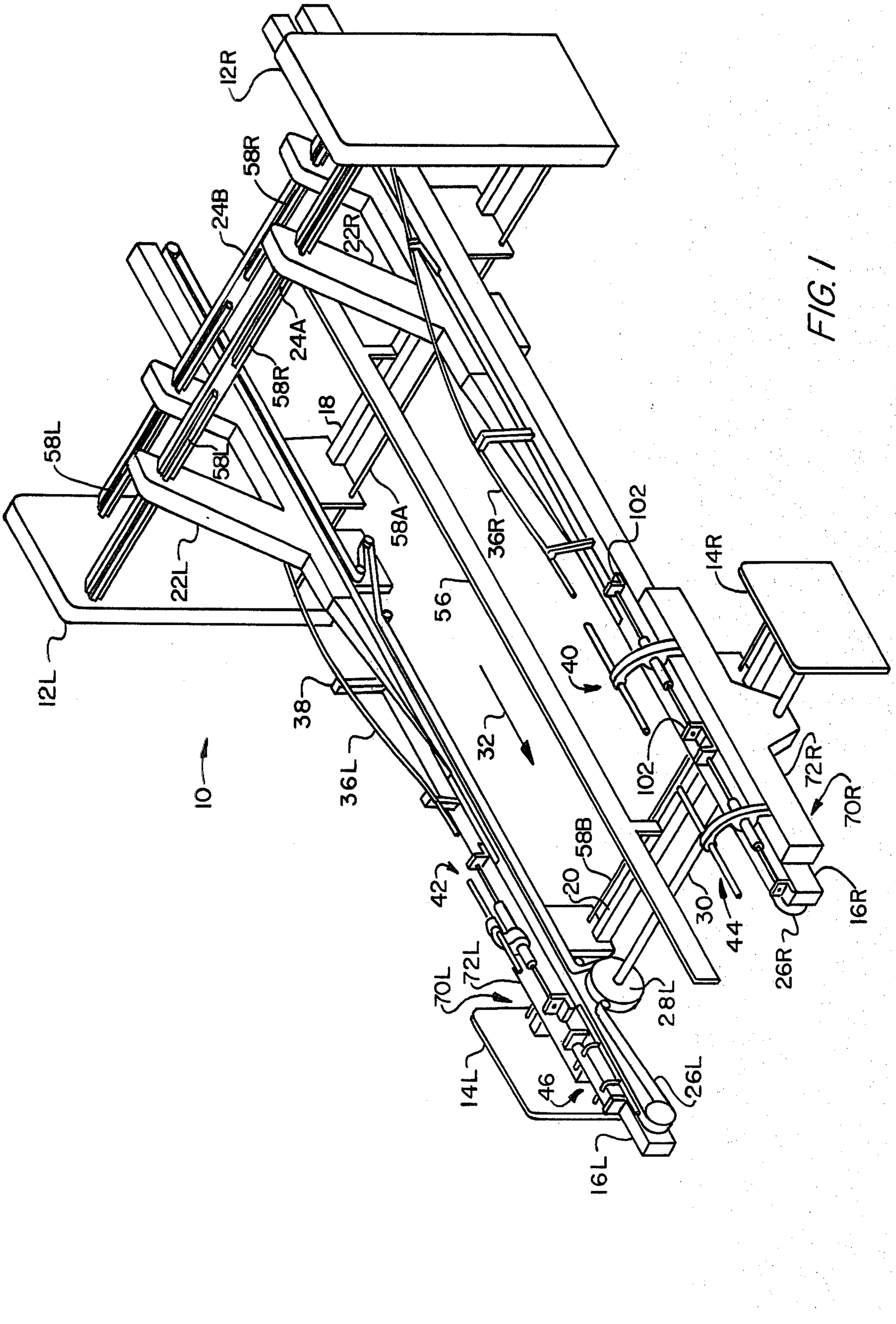
Primary Examiner—James F. Coan
Attorney, Agent, or Firm—Boyce C. Dent

[57] **ABSTRACT**

A belt type box blank folding machine including bar folder assemblies on a downstream end thereof for engaging partially folded substantially upstanding outer panels on the blanks and folding them downward against inner panels of the blanks. The bar folders are arranged to pivot from an upright position, in engagement with the upstanding panels, to a horizontal position and to simultaneously reciprocate along the path of blank travel to provide maximum engagement with the outer panels during folding thereof. The bar folders are parallel with the fold line of the outer panels during folding thereby preventing twisting of the panels and locking of the leading flaps of the outer panels against the inner panels.

10 Claims, 15 Drawing Figures

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58R
24B
22R
24A
58R
18
58L
58L
58L
58A
36R
56
102
14R
22L
12L
38
36L
10
32
40
102
72R
70R
16R
42
58B
20
30
44
26R
70L
72L
14L
46
28L
26L
16L

FIG. 1

FIG. 2

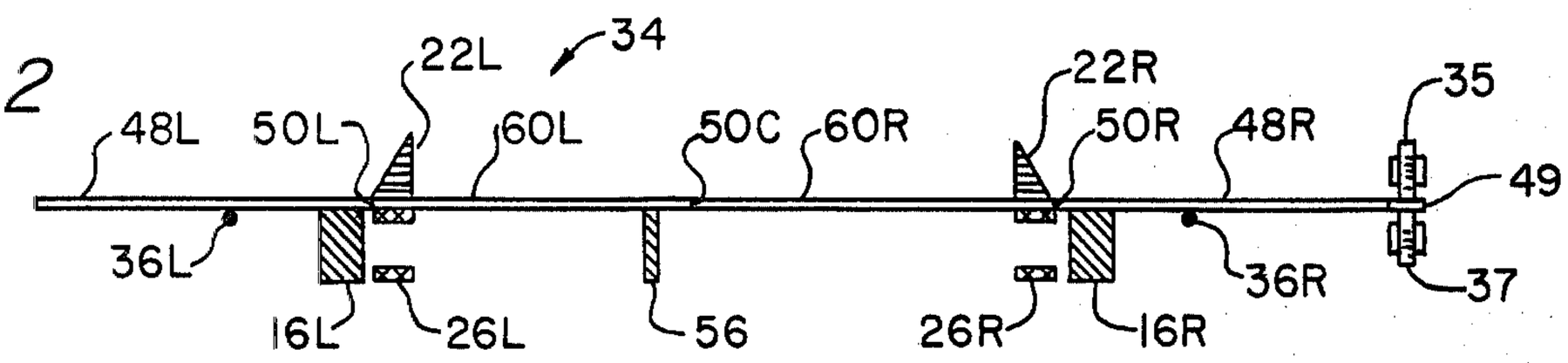


FIG. 3

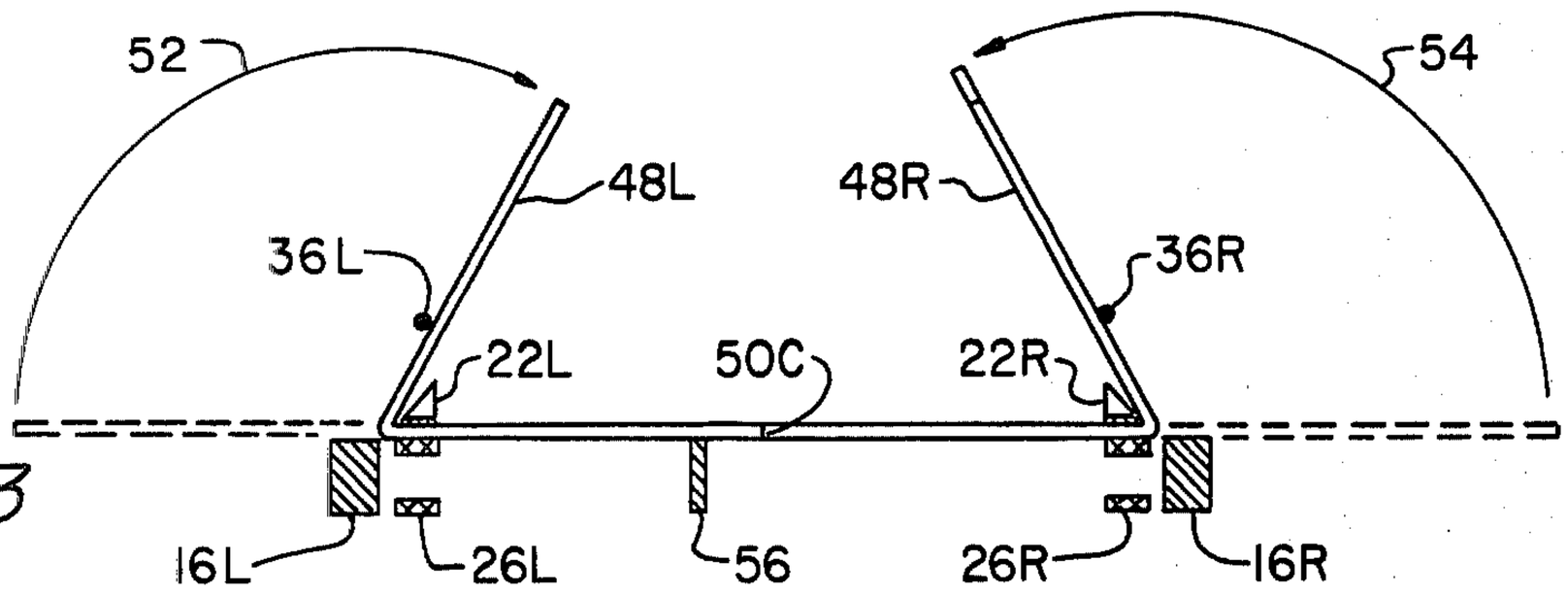


FIG. 4

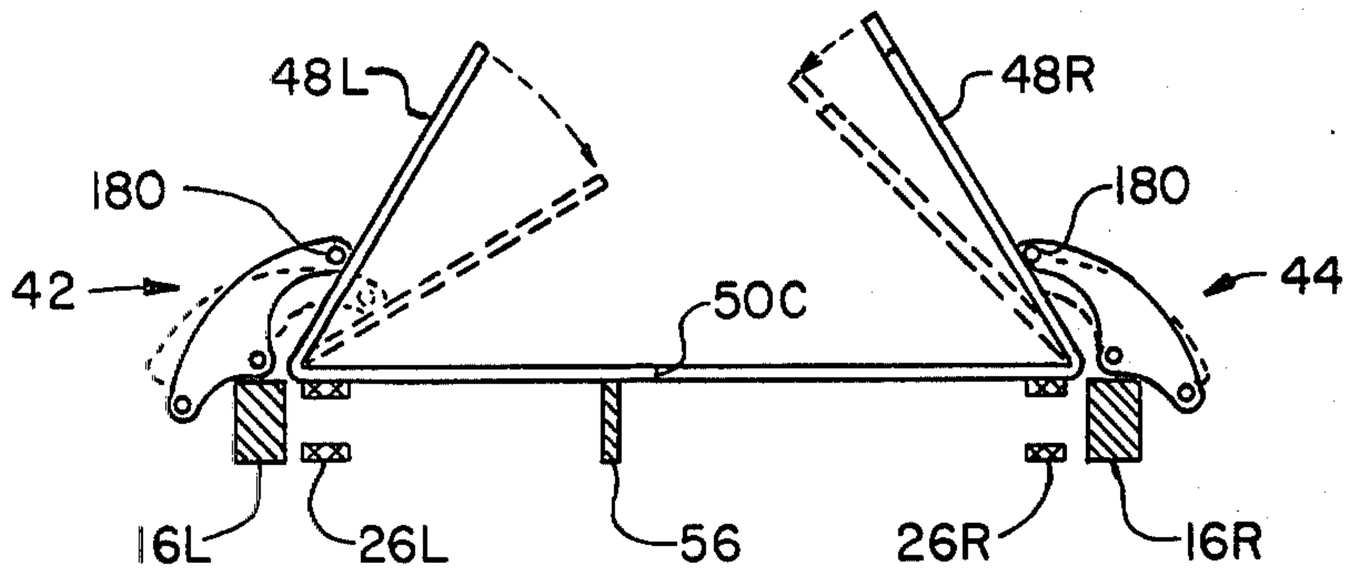
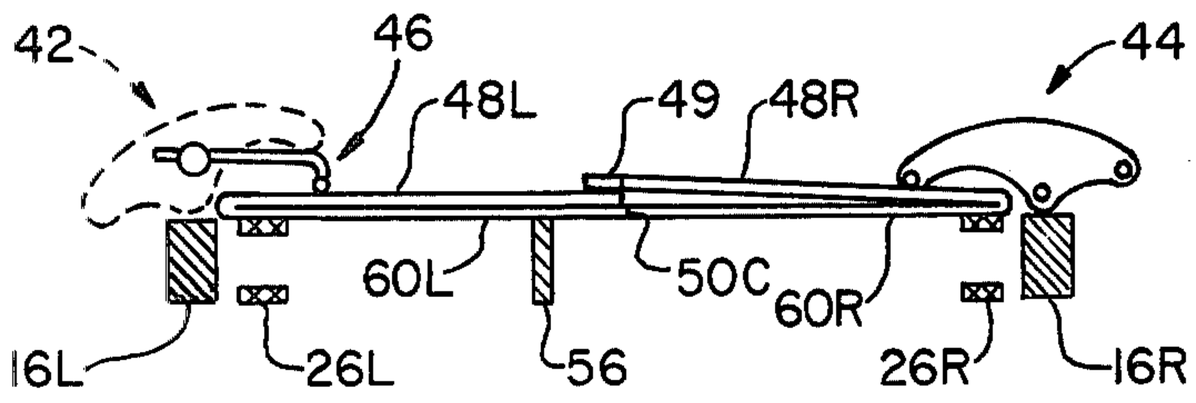


FIG. 5



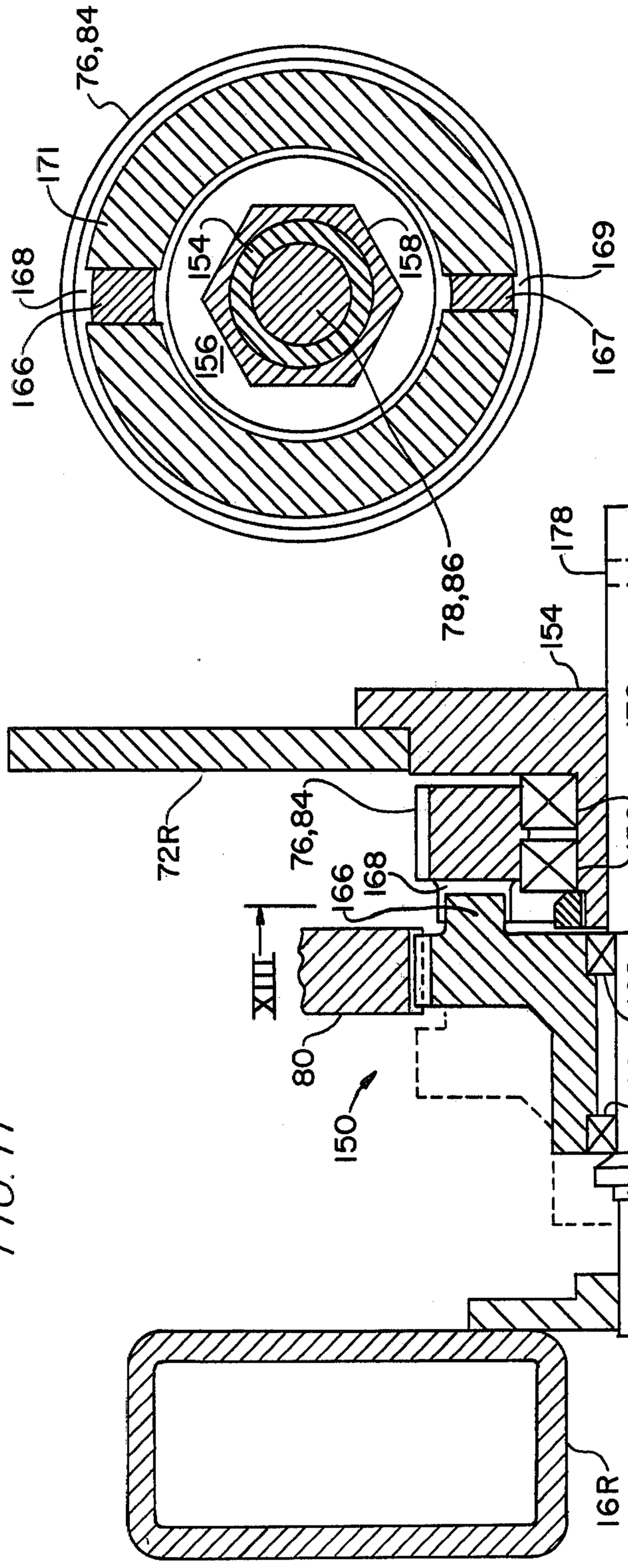


FIG. 13

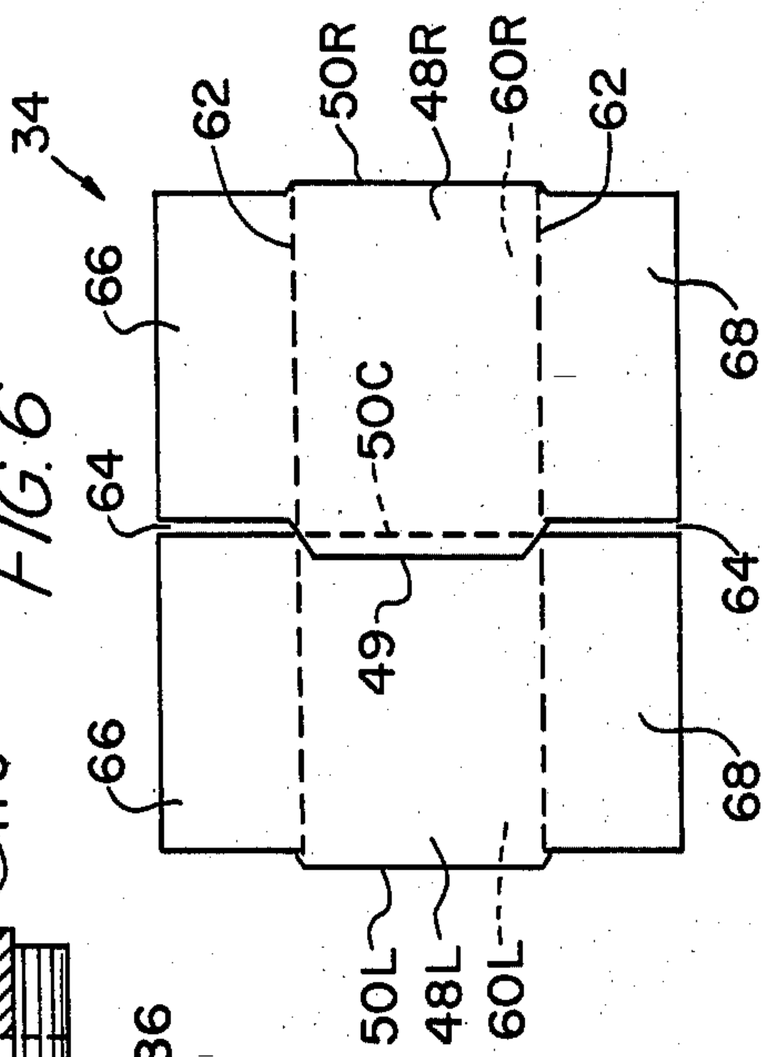
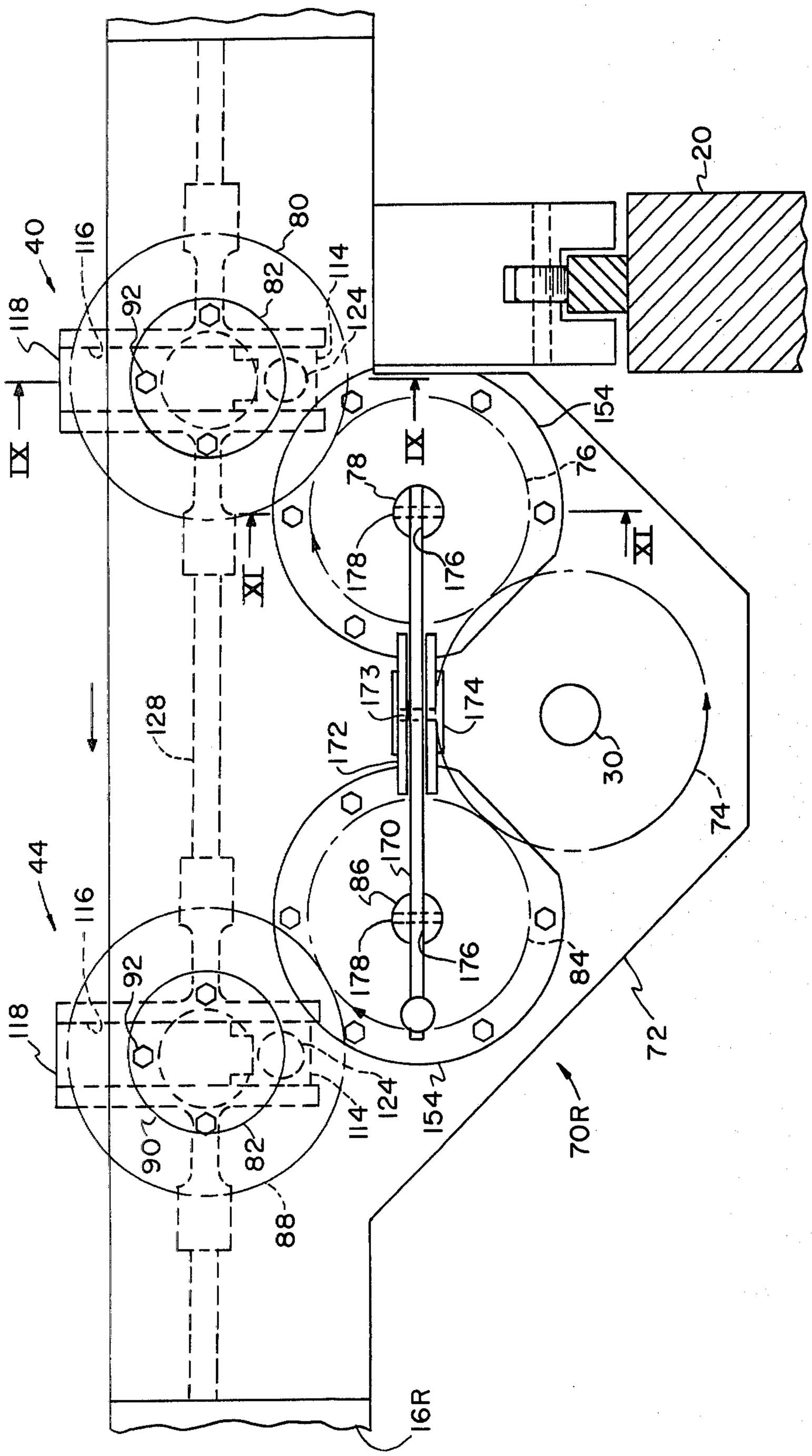


FIG. 6

FIG. 7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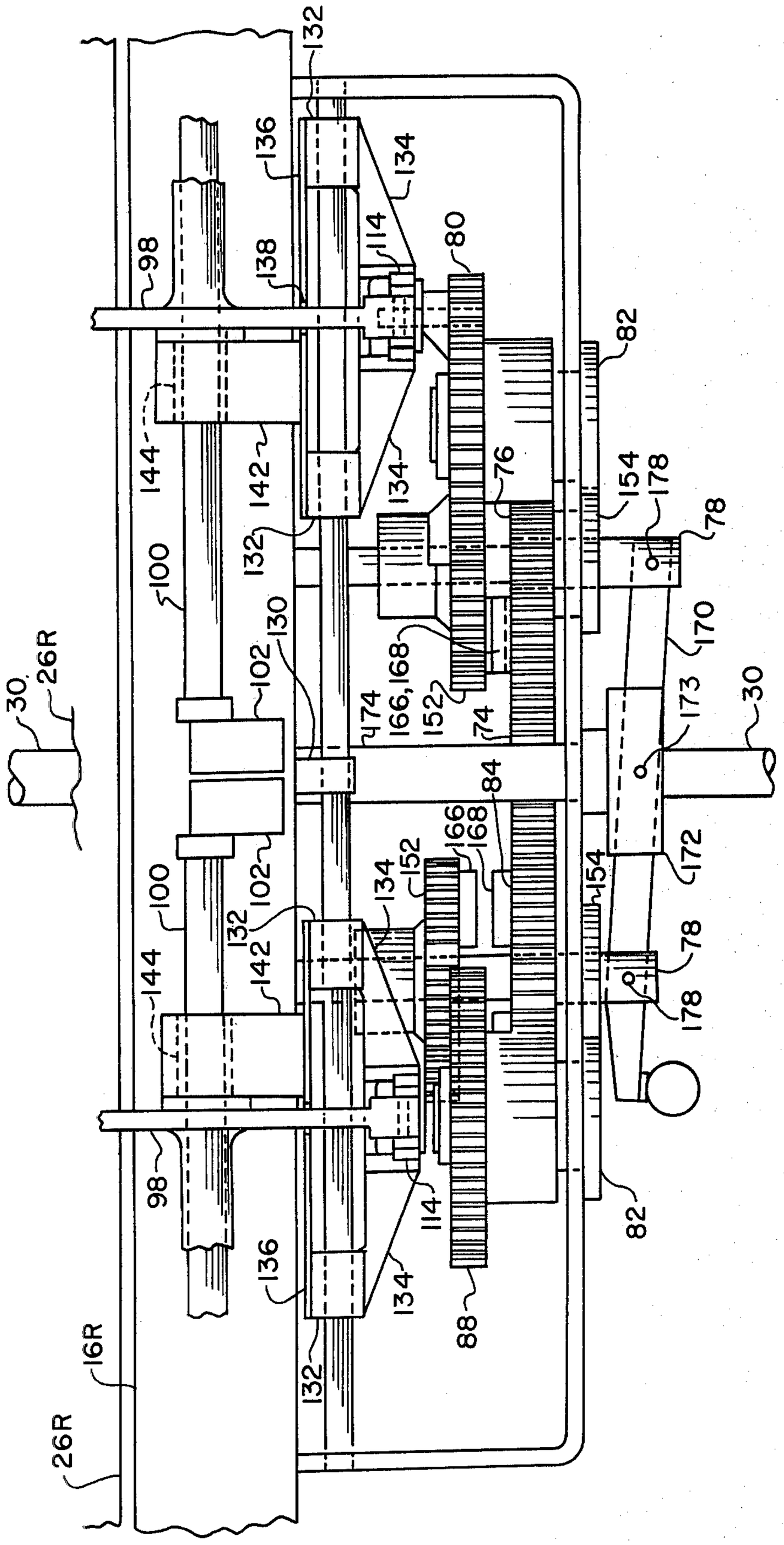
40
116
80
114
118
92
82
124
IX
XI
154
78
76
178
176
173
174
172
30
74
44
128
170
86
84
72
70R
90
88
16R

FIG. 7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136
134
114
80
98
138
82
144
142
134
76
154
178
78
132
100
102
130
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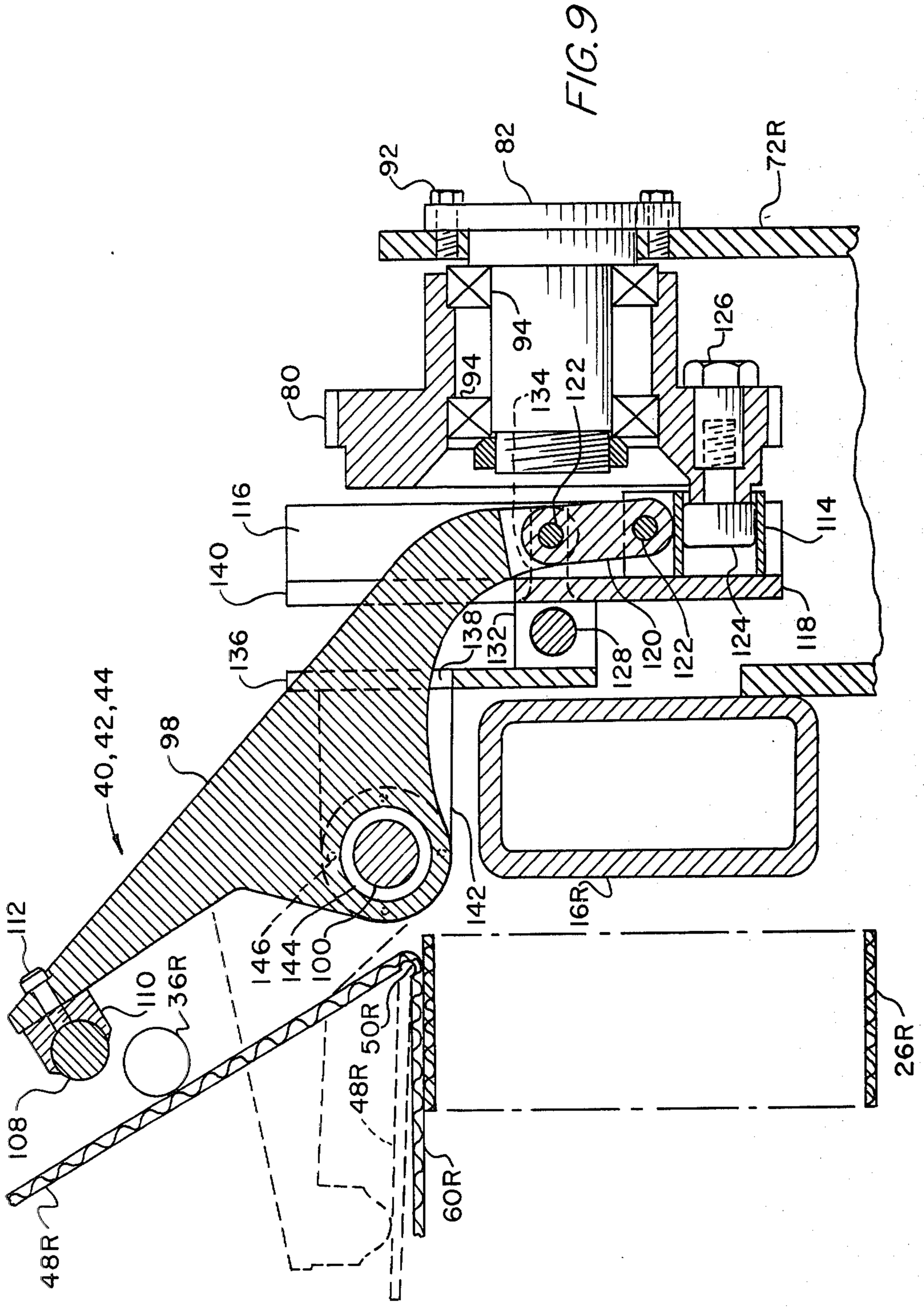
26R
474
166,168
152
74
170
173
84
166
168
134
152
154
172
144
100
102
132
142
78
178
98
114
136
134
88
16R
26R
82

FIG. 8

FIG. 9


92
82
72R
94
126
80
94
134
122
116
114
140
138
132
136
128
120
122
124
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144
100
48R
50R
108
48R
60R
26R

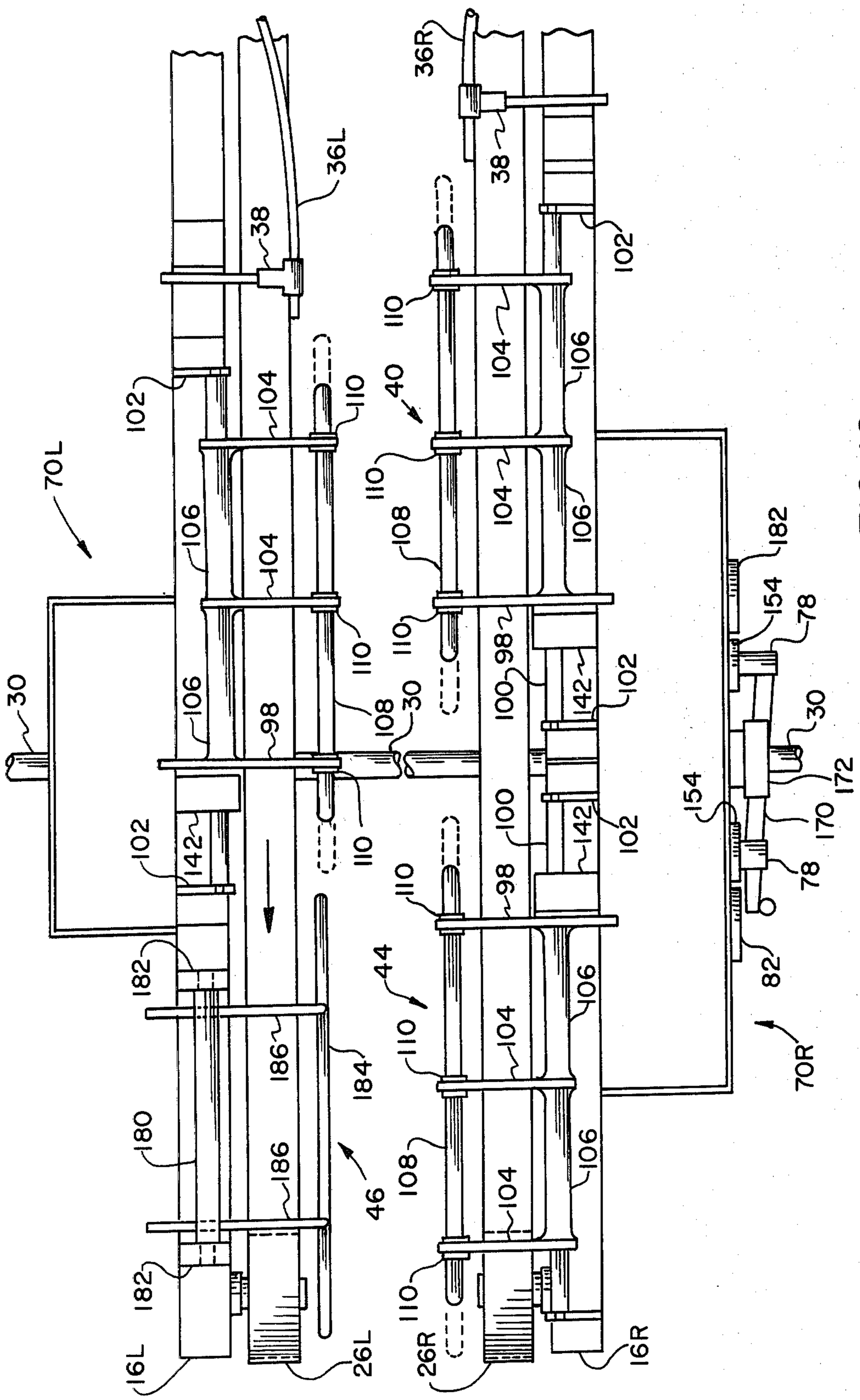

70L
36L
36R
38
102
104
106
108
110
40
30
98
100
142
182
184
186
180
44
46
16L
26L
26R
16R
154
78
170
172
82
70R

FIG. 10

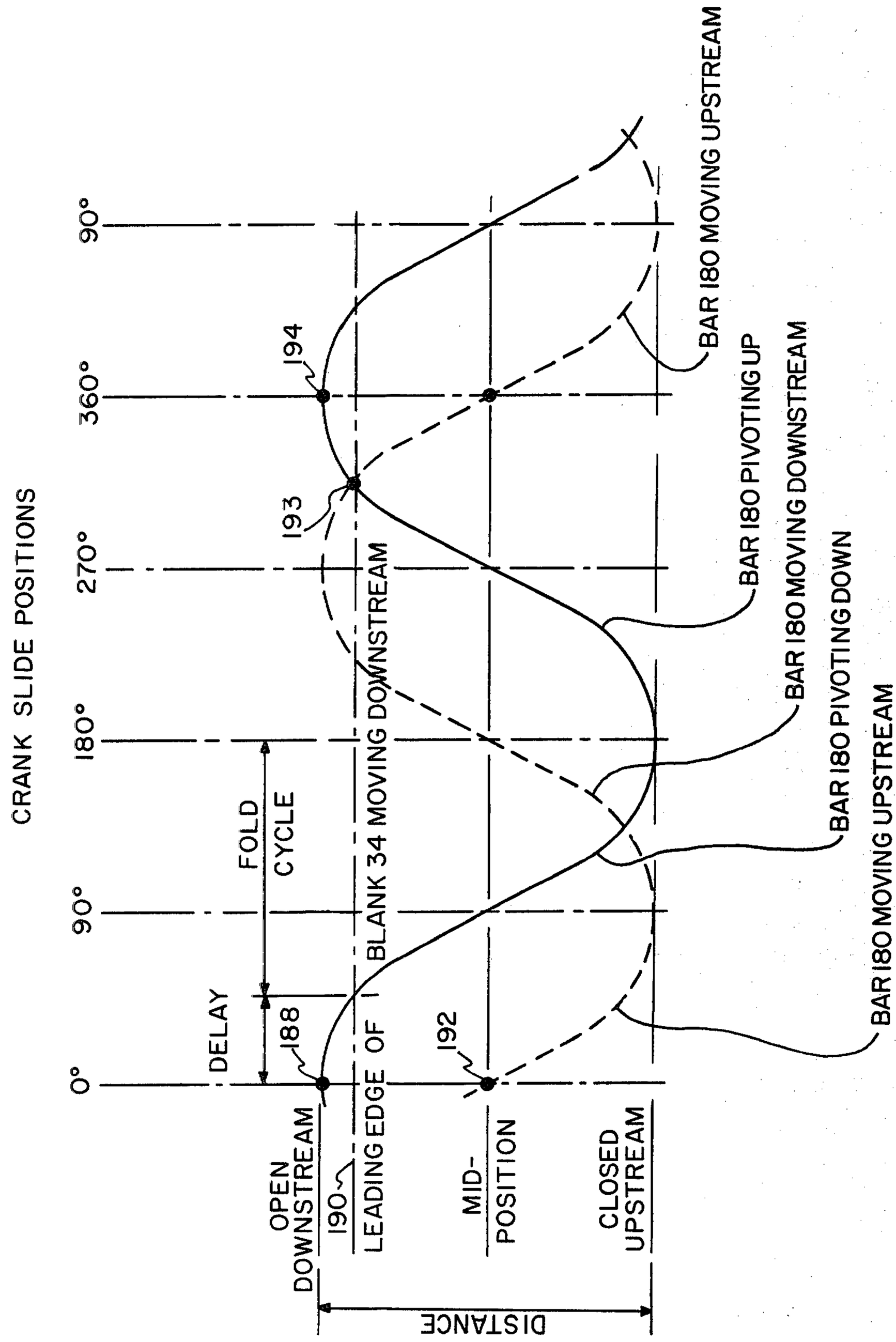

CRANK SLIDE POSITIONS
0°
90°
180°
270°
360°
90°
DELAY
FOLD
CYCLE
188
192
193
194
190
OPEN DOWNSTREAM
LEADING EDGE OF BLANK 34 MOVING DOWNSTREAM
MID-POSITION
CLOSED UPSTREAM
DISTANCE
BAR 180 MOVING UPSTREAM
BAR 180 PIVOTING UP
BAR 180 MOVING DOWNSTREAM
BAR 180 PIVOTING DOWN
BAR 180 MOVING UPSTREAM

FIG. 12

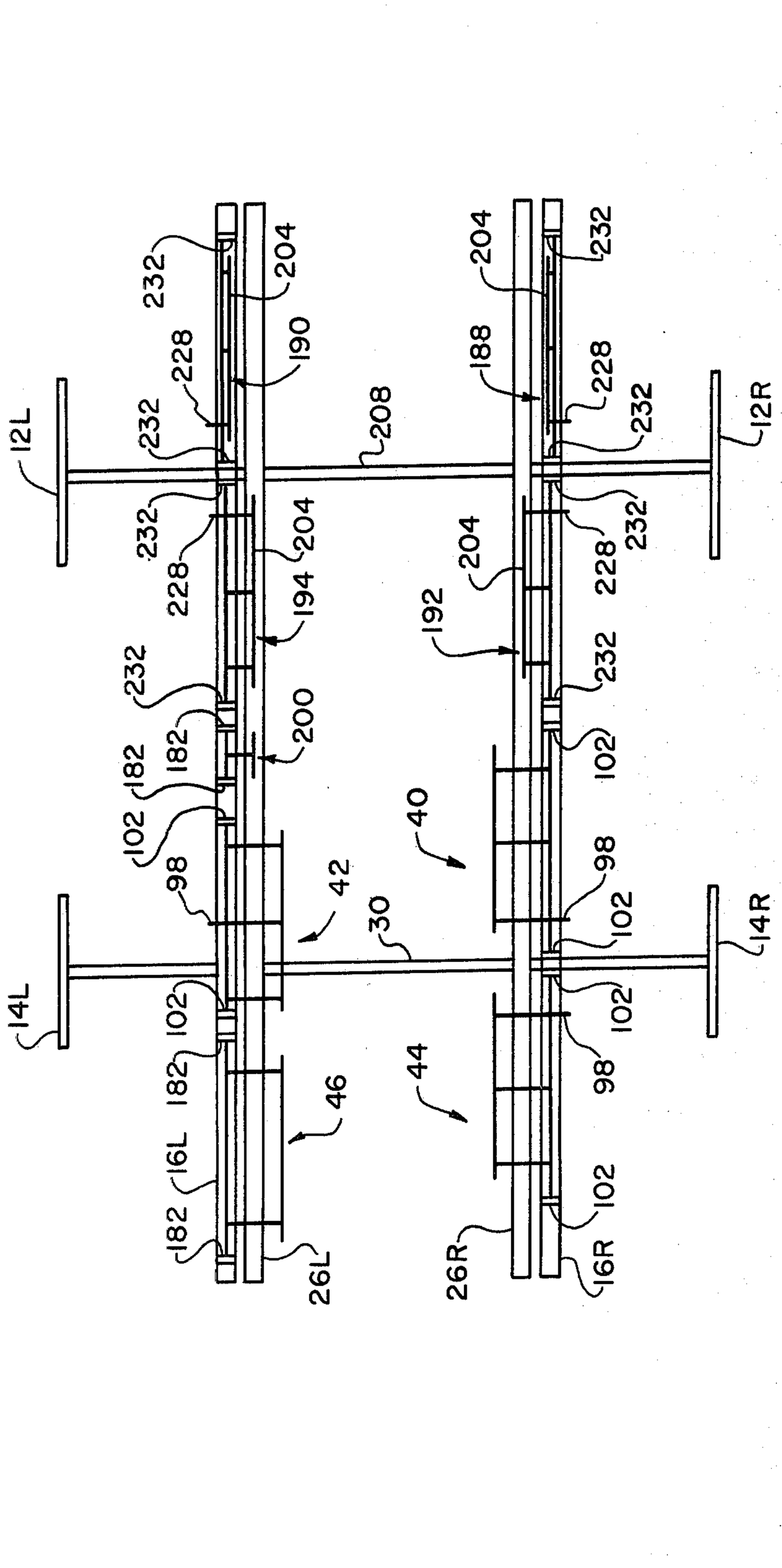
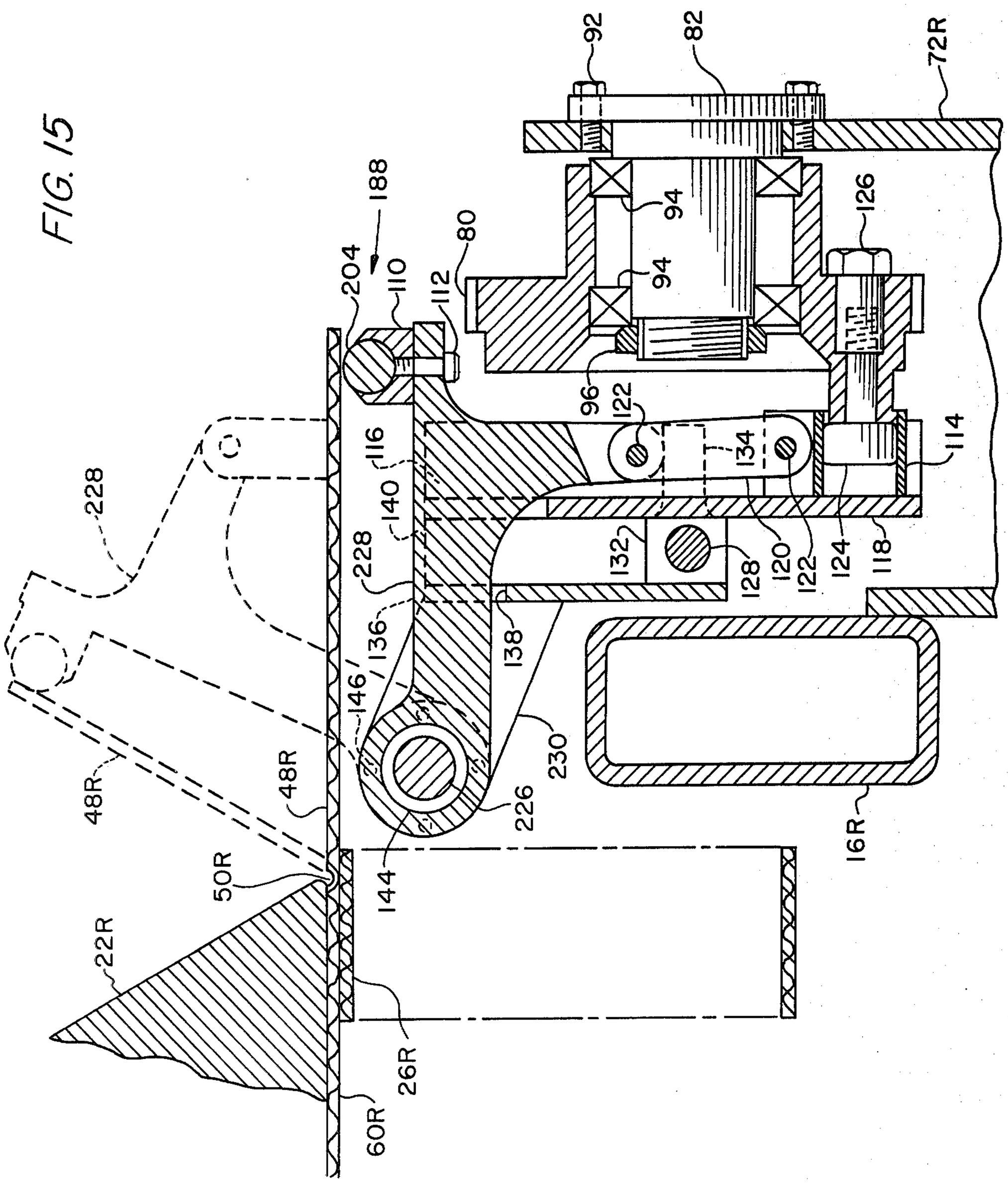

12L
232
228
232
228
232
204
190
208
204
188
204
232
228
232
12R
232
204
194
204
192
204
228
232
232
200
182
182
102
102
98
42
40
98
102
30
14L
14R
102
182
102
46
44
98
102
16L
182
26L
26R
102
16R

FIG. 14

FIG. 15


92
82
72R
188
204
110
112
80
94
94
126
96
122
134
114
116
140
228
132
128
120
122
124
118
228
136
138
146
230
48R
48R
226
50R
144
22R
26R
60R
16R

BOX BLANK FOLDING APPARATUS

BRIEF SUMMARY OF THE INVENTION

This invention is directed to apparatus for folding corrugated paperboard blanks. The apparatus generally comprises a substantially conventional belt type folder modified in accordance with this invention to permit folding of flat, continuously advancing blanks of flimsy corrugated or similar paperboard material. The apparatus includes laterally spaced endless conveyors supported for rotation on adjacent lower rails; upper folding rails spaced above the endless conveyors defining edges against which outer panels of the blanks advancing along the endless conveyors may be folded to an upright position; and flexible folding rods beginning at an infeed end of the folder alongside the lower rails and beneath the panels to be folded, such rods extending in serpentine fashion to where they are spaced above the endless conveyors so as to fold the outer panels of the blanks to an upright position. Rather than continue downward over the inner panels of the blanks, as in a conventional folder, the rods terminate at the point where the outer panels are folded upright. At this point, a bar folder assembly is pivotally and reciprocably mounted to each of the lower rails. The bar folders are arranged to engage the upstanding outer panels of the advancing blanks and fold them downward to a horizontal position above the inner panels of the blank. Adhesive previously applied to a tab on one outer panel contacts the other outer panel and adheres thereto thereby forming a folded, flat, tubular blank which is discharged from the apparatus for further handling such as stacking and bundling.

Folding of the outer panels from an upright to a horizontal position is accomplished by pivoting the bar folders downward and simultaneously reciprocating them in an upstream and downstream direction during pivoting. The apparatus is arranged to move the bar folders upstream during the first portion of downward pivotal movement; this permits the bars to rapidly engage a substantial portion of the outer panel of the blank, since the blank continues to move downstream. This provides a relatively long area of engagement with the panel so that it can be folded by parallel contact with the bar as it reverses direction and moves downstream with the blank. Such engagement prevents bending of the front edge or flap of the outer panel such as sometimes occurs when only folding rods are used as in conventional folders. Thus, flimsily constructed blanks can be folded without twisting because of the flat contact provided by the pivotable bar folders; in addition, the reciprocation of the folder bars maintain substantially continuous contact with the panels and the blanks may continue to move uninterruptedly at high speeds.

In conventional practice, one outer panel is sometimes folded downward to rest on top of the opposite panel and sometimes folded to rest beneath the opposite panel. In the preferred construction of this invention, one folding bar is ahead of the opposite folding bar in the upstream direction. Thus, the panel contacting the upstream bar will be folded first so that the subsequently folded panel will be folded on top of it. However, a third folding bar is located downstream from the first bar; when the first bar is deactivated (as will be described), the second bar folds its panel first so that the other panel is folded on top of it by the third bar.

The apparatus includes a drive shaft extending between the lower rails. The drive shaft is arranged to drive the endless conveyor belts. In addition, it is connected through a gear train and crank assembly to the folding bars to pivot and reciprocate them. A selector lever is provided to selectively operate the first and second bar folder or the second and third bar folder to cause the desired outer panel to be folded before the other.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings wherein like parts are marked alike:

FIG. **1** is an isometric illustration of the complete folding apparatus of this invention;

FIG. **2** is a diagrammatic illustration looking upstream toward the oncoming blanks entering the folding apparatus of FIG. **1**;

FIG. **3** is a diagram similar to FIG. **2** showing the position of the outer panels of the blank at the end of the folding rods;

FIG. **4** is a diagram similar to FIG. **3** showing the position of the outer panels of the blank at the beginning and partly through the fold made by the pivotable bar folder;

FIG. **5** is a diagram similar to FIG. **4** showing the position of the outer panels and the pivotable bar folder after the outer panels have been completely folded;

FIG. **6** is a top view of a blank in its completely folded position after being folded by the apparatus of FIG. **1**;

FIG. **7** is a side elevation view partially illustrating the gear and crank arrangement used to pivot and reciprocate the bar folders from the drive shaft;

FIG. **8** is a top view of the apparatus of FIG. **7**;

FIG. **9** is a detailed view of the pivot mechanism for the bar folders taken along line IX—IX of FIG. **7**;

FIG. **10** is a top view of the bar folders showing their location on both sides of the folding apparatus;

FIG. **11** is a detailed view of the clutch mechanism for the bar folders taken along line XI—XI of FIG. **7**;

FIG. **12** is a sine wave diagram illustrating the pivotal position of the bar folders relative to their reciprocable position;

FIG. **13** is a section view of a portion of the clutch mechanism of FIG. **11** taken along the line XIII—XIII;

FIG. **14** is a diagrammatic top view of the folding machine illustrating the use of bar folding assemblies rather than flexible folding rods on the upstream end of the machine; and

FIG. **15** is a detailed view of the pivot mechanism for the bar folders of FIG. **14** taken along line XV—XV of FIG. **14**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. **1**. the folder-gluer machine generally denoted by numeral **10** includes a pair of upstream side frames **12L** and **12R** and smaller downstream side frames **14L** and **14R**. A pair of lower folding rails **16L** and **16R** are supported by an upstream guideway **18** and a downstream guideway **20**, both of which extend laterally between their respective side frames. A pair of upper folding rails **22L** and **22R** are supported on upstream guideways **24A** and **24B** which extend laterally between side frames **12L** and **12R**. A pair of endless conveyor belts **26L** and **26R** are mounted for rotation

on the inboard side of their respective lower folding rails **16L** and **16R**. The belts **26L** and **26R** are driven by drive pulleys **28L** and **28R** (**28R** obscured from view) which are mounted for driven rotation on drive shaft **30**. A jackshaft (not shown) is connected to drive shaft **30** along the left side of the folder **10**. The jackshaft is customarily connected to an upstream box machine (not shown) that is immediately adjacent to the upstream end of the folder **10**. The box machine is driven by a main drive motor (not shown) which also drives the folder **10** by the jackshaft arrangement just described. The conveyor belts **26L** and **26R** are arranged so that their upper flights travel in the downstream direction indicated by arrow **32**. These belts serve to serially advance a succession of box blanks **34** (shown in FIGS. **2–5**) through the folder **10** in which the outer panels of the blanks are folded as will be described.

A pair of flexible folding rods **36L** and **36R** are supported on the lower folding rails **16L** and **16R** by a number of supports, secured to the folding rails **16L** and **16R**, of which one is denoted by numeral **38**, the remainder being substantially identical. The rods **36L** and **36R** begin alongside and outboard of the infeed end of the conveyor belts **26L** and **26R** as shown in FIGS. **1–2** and extend downstream in serpentine fashion, as shown in FIG. **1**, to a position above the top surfaces of the respective conveyor belts **26L** and **26R** where they terminate as shown in FIG. **1**.

A bar folder assembly generally denoted by numeral **40** is pivotally and reciprocably mounted to lower rail **16R** just downstream from the terminus of folding rod **36R**. A similar second bar folder assembly **42** is mounted substantially opposite to but downstream of the first folding bar assembly on the lower rail **16L** just downstream from the terminus of folding rod **36L**. A similar third bar folder assembly **44** is mounted to lower rail **16R** just downstream from folder assembly **40** as shown in FIG. **1**. A blank hold-down bar assembly **46** is mounted to lower rail **16L** just downstream from the second bar folding assembly **42**; the hold-down bar is adjustable as to height above the belt **26L** and laterally across the width of the machine but does not pivot nor reciprocate.

The blanks **34** to be folded enter the upstream end of the folder **10** in a flat, open condition (see FIG. **2**) and are advanced therethrough by belts **26L** and **26R**. As the blanks **34** enter the folder **10**, adhesive is applied to a glue tab **49** (see FIG. **2** and FIG. **6**) on the blanks (adhesive applicator obscured by side frame **12R**; shown schematically in FIG. **2** by glue wheels **35** and **37**). Thereafter, the blanks **34** advance downstream; as they do, the outer panels **48L** and **48R** are first folded to a substantially upright position (see FIG. **3**) by folding rods **36L** and **36R**, the panels being folded along score lines **50L** and **50R** which have been made in the blanks **34** by the aforementioned box machine. These score lines are in substantial alignment with the lower outer edges of the upper folding rails **22L** and **22R** as best shown in FIG. **2**. Folding of the outer panels is caused by their sliding against the folding rods **36L** and **36R** which are curved as shown in FIG. **1** so that the panels rise from their initial horizontal position as shown in FIG. **2** to the upright position shown in FIG. **3**. The arrows **52** and **54** denote the fold angle which is preferably about 120° from horizontal; folding to this position is caused by folding rods **36L** and **36R** as previously described.

It should be recognized that the folding rod supports **38** are usually adjustable (detailed adjustment not shown) in the conventional manner to vary the fold angle as desired. Such adjustment is used to control folding of the outer panels **48L** and **48R** depending on their size, which may vary from order to order, and amount of warp as well understood by those skilled in the art. The folding rods **36L** and **36R** are usually flexible, being made of nylon or similar plastic material, so that they follow the position of supports **38**. However, the folding rods may be rigid if desired and bent to the shape required to fold the panels or even be straight rods that are held in a skewed position relative to the direction of blank travel.

A center support **56** extends between and is mounted on guideways **18** and **20** as shown in FIG. **1** to support the center of the advancing blanks **34** to prevent them from buckling from their own weight. This support is not usually adjustable, but remains near the lateral center of the folder **10**. It should also be noted here that the blanks **34** include a center score line **50C** which, for the configuration of the blank depicted, moves alongside the center support **56**. The center score is always in the lateral center of this type machine; therefore, placing the center support **56** slightly off center prevents the score **50C** from riding on it to prevent skewing.

The lower folding rails **16L** and **16R**, which also support the folding rods **36L** and **36R** and conveyor belts **26L** and **26R**, are adjustable toward and away from the lateral center of folder **10** to position them for alignment with the score lines **50L** and **50R** in the blanks being folded, it being understood that the aforementioned box machine is capable of processing blanks of different sizes. The upper folding rails **22L** and **22R** are likewise adjustable for the same reason. Adjustment of the lower rails is achieved by the use of motorized screw shafts **58A** and **58B** passing through conventional ball nuts (not shown) in the supports for such members. The screw shafts **50A** and B are similar but may vary with respect to length, location, and the side of the folder **10** from which they are driven. In addition, it is not believed necessary to identify the individual supports for the various rails since their location and function are readily apparent from FIG. **1** to those skilled in the art. If desired, conventional spur tooth racks mounted on the cross members **18** and **20** may be used to position the lower rails instead of the screw shafts **58A** and **58B**. If so, the rails **16L** and **16R** will include spur tooth pinions (not shown) in driven engagement with the racks.

Spur tooth racks **58L** and **58R** may be mounted to the supports **24A** and **24B**, similar to that just described, for lateral positioning of the upper rails **22L** and **22R**. The upper rails include spur tooth pinions (not shown) in driven engagement with the racks to move the rails as will be readily understood by those skilled in the art. The racks **58L** and **58R** terminate near the center of the supports **24A** and **24B**; individual spur tooth drives as mentioned above permit the rails to be adjusted individually for proper positioning to obtain the best folding of the blanks.

After the blanks **34** reach the position shown in FIG. **3** with the outer panels **48L** and **48R** in a substantially upright position, they advance between the bar folder assemblies **40** and **42** shown in FIG. **1**. At this point, it should be understood that one of the outer panels **48L** and **48R** must be folded downward ahead of the other against the inner panels **60L** and **60R** because the glue

tab **49** must be either on the top of or beneath the panel **48L** to glue the tab to the panel. When the tab **49** rests on top of panel **48L**, an outside glue joint is formed; when it rests beneath the panel, an inside glue joint is formed. The glue wheels **35** and **37** may be reversed to apply adhesive to either the top or bottom of tab **49** to provide either an inside or outside glue joint. Thus, if an inside glue joint is to be formed, outer panel **48R** is folded first by pivoting of bar folding assembly **40** (FIG. **1**) and then outer panel **48L** is folded over it by pivoting of bar folder assembly **42** (FIG. **1**). In this instance, after folding, the folded panel **48L** is held against the inner panel **60L** and on top of the glue tab **49** by the hold-down bar assembly **46** (FIG. **1**) as the blank **34** advances out of the machine. The bar folder assembly **44** is not pivoted in this sequence since outer panel **48R** has been folded by bar folder assembly **40**.

Conversely, if an outside glue joint is to be formed, outer panel **48L** is folded first by pivoting of bar folder assembly **42** and then outer panel **48R** is folded over it by pivoting of bar folder assembly **44**. In this instance, the hold-down bar assembly **46** need not be used since the last folded panel **48R** is held down by bar folder assembly **44** as the blank **34** advances out of the machine. The bar folder assembly **40** is not pivoted in this sequence since outer panel **48R** is folded last by bar folder assembly **44**. The alternate operation of bar folder assemblies **40** and **44** will be subsequently explained.

It should be understood that the blanks **34** are fed through the box machine (not shown) at fixed timed intervals; since the folder **10** is driven by the box machine, the blanks travel through it at the same intervals. Thus, once the bar folders **40**, **42**, and **44** are adjusted, by disengaging a clutch as will be explained, to begin pivoting downward to fold the outer panels **48L** and **48R** as they reach the selected one of the bar folders **40** or **42**, no further adjustments are required. That is, the bar folders **40** or **42** will begin pivoting at the same timed intervals that the blanks reach them.

Referring now to FIG. **4**, the blank **34** is shown being advanced beneath bar folder assemblies **42** and **44** with the outer panel **48L** being folded first to form an outside glue lap. Because bar folder assembly **42** is upstream, although on the opposite side from bar folder assembly **44**, the outer panel **48L** is folded to the dotted line position by pivoting of assembly **42** and panel **48R** is folded to the dotted line position by assembly **44**. Pivoting of assemblies **42** and **44** continues until the panels **48L** and **48R** are completely folded over the inner panels **60L** and **60R** as shown in FIG. **5**. The blank **34** advances out of the machine in this flat tubular configuration as illustrated in FIG. **6**. The blank **34** also includes transverse score lines **62** and **64** thereby creating top and bottom flaps **66** and **68** which, when the folded and glued blank is opened, form the top and bottom of a complete box as is well understood by those skilled in the art.

The apparatus provided for pivoting and reciprocating the bar folder assemblies **40**, **42**, and **44** is illustrated in FIGS. **7–11**. The drive shaft **30** shown in FIG. **1** passes through a main gear and crank arrangement, generally denoted by numeral **70L** on the left side of FIG. **1** and **70R** on the right side, which are supported on the lower rails **16L** and **16R** respectively by support enclosures **72L** and **72R**. Referring to FIG. **7**, a conventional spur tooth gear **74** is secured for rotation on drive shaft **30** inside enclosure **72R**. A similar gear **76** is supported for rotation about a stub shaft **78** and is driven engagement with gear **74**. Another gear **80** is supported for rotation about a stub shaft **82** and in driven engagement with gear **76**. The gears rotate in the direction indicated by the arrows on the pitch circle of the gears. This set of gears **74**, **76**, and **80** is used to pivot and reciprocate bar folder assembly **40** as will be subsequently explained in connection with FIGS. **8** and **9**. A similar set of gears and associated apparatus are supported in enclosure **72L** for pivoting and reciprocating bar folder assembly **42**; since the parts are identical, they are not shown and the description of the above arrangement will suffice for the gear arrangement for bar folder assembly **42**.

Still referring to FIG. **7**, a similar set of gears is used to pivot and reciprocate bar folder assembly **44**. More specifically, a gear **84** is supported for rotation about a stub shaft **86** and in driven engagement with gear **74** on drive shaft **30**. Another gear **88** is supported for rotation about a stub shaft **90** and in driven engagement with gear **84**. These gears rotate in the direction indicated by the arrows and are used to pivot and reciprocate bar folder assembly **44**.

Referring now to FIG. **9**, stub shaft **82** is mounted to the outer wall of enclosure **72R** by screws **92** as shown. Gear **80** is supported for rotation about stub shaft **82** by conventional bearings **94**. The gear **80** is retained on shaft **82** by a nut **96** threaded on the shaft against one bearing **94**.

Only one of the bar folder assemblies **40**, **42**, and **44** will be described since they are all similar. Still referring to FIG. **9**, bar folder assembly **40** includes a pivot arm **98** pivotable about a pivot shaft **100**. Pivot shaft **100** is supported on top of lower rail **16R** by shaft supports **102** (shown on FIG. **1**). The pivot arm **98** preferably includes additional spaced arm segments **104** connected by tubular portions **106** surrounding pivot shaft **100** as shown on FIG. **10** which is a top view of a portion of the assembly. A folding rod **108** is secured to pivot arm **98** and segments **104** by short blocks **110** held in place by screws **112** as shown on FIG. **9**. Thus, a pivot arm **98** is pivoted, the rod **108** moves from the upright position shown in solid lines on FIG. **9** to the dotted line position thereby folding the outer panel **48R** to the dotted line position.

Pivoting of pivot arm **98** is accomplished by connecting it to a crank slide **114** which moves up and down in a groove **116** in a slide block **118**. Pivot arm **98** is connected to crank slide **114** by a link **120** which is itself connected by pins **122** to both the arm **98** and crank slide **114**. The link **120** permits the adjacent end of arm **98** to move in an arc as it is pivoted up and down.

The crank slide **114** is caused to move up and down by a bearing **124** which is secured to a stud **126** passing through the gear **80** as shown on FIG. **9**. It can be seen that as gear **80** rotates, the bearing **124** will revolve about the central axis of the gear thereby causing the crank slide **114** to move up and down in the groove **116** and, as it does, pivot the pivot arm **98**. A front view of this arrangement appears diagrammatically on FIG. **7**.

It can also be seen, referring to FIG. **9**, that as the gear **80** rotates, carrying the bearing **124** with it, the slide block **118** must move in a horizontal direction; otherwise, the assembly would bind up. This necessary motion is used to reciprocate the bar folder assembly **40**. This is achieved by mounting the slide block **118** on a slide rod **128**. Slide rod **128** is secured to the side face of lower rail **16R** by a center support block **130** with the ends of slide rod **128** supported in the ends of enclosure

72R as shown on FIG. 8. Thus, as the gear **80** rotates, the revolving movement of bearing **124** causes the crank slide **114** to move up and down, as previously described, and also causes the slide block **118** to move horizontally along slide rod **128** thereby creating a compound motion of pivoting and reciprocation of the bar folder assembly **40**.

Referring to FIGS. **8** and **9**, the crank slide **118** is connected for sliding engagement along rod **128** by two blocks **132** spaced from the crank slide groove **116** by webs **134**. The blocks **132** stabilize the slide block **118** and prevent it from binding as it reciprocates along the rod **128**. A plate **136** spans the distance between blocks **132** and is connected thereto in any convenient manner. Plate **136** includes a notch **138** through which pivot arm **98** passes. Slide block **118** includes a similar notch **140** for the same purpose. A rod support **142** is mounted to plate **136** and extends over lower rail **16R** (as shown in FIG. **9**) and surrounds rod **100**. A bushing **144** is secured to pivot arm **98** such as by screws **146** and is also retained within rod support **142**. Thus, as slide block **140** is caused to reciprocate along rod **128** as previously explained, it reciprocates pivot arm **98** along rod **100** via the connection provided by the plate **136**, rod support **142**, and bushing **146**. At the same time, the pivot arm **98** pivots about rod **100** via its connection to bushing **144** which slides along the rod and pivots about it.

FIG. **12** is a diagram illustrating the simultaneous reciprocation of and pivoting of bar folder assemblies **40**, **42**, and **44** as blanks **34** advance beneath them. This diagram corresponds to the position of the crank slide **114** shown in FIG. **7** where, with the crank slide in the down position, the rod **108** of the folding assembly **40** (for example) is fully up at the beginning of the cycle denoted 0°. It should be understood that the flexible rod **36R** (FIG. **3**) folds the outer panel **48R** through the fold angle **54** a distance sufficient to permit the leading edge of the blank **34** to pass beneath the folding rod **108** without interference when the folding bar assembly **40** is pivoted fully up and the rod **108** is in its midposition during its upstream reciprocation. The clearance between folding rod **108** and outer panels **48L** and **48R** is shown in FIG. **4**; this same clearance is diagrammatically illustrated in FIG. **12** where the full up position of the bar folder assembly is denoted by the point **188** when the crank slide **114** is at the 0° position. At that point, the phantom line **190** illustrates that the leading edge of the blank **34** clears the folding rod **108** as the leading edge of the blank crosses the 0° position of the folding assembly **40**; this clearance is indicated as a "delay" before the rod **108** engages the panel **48R**. It can be seen that the folding rod **108** is in the midposition of its upstream stroke at the 0° position of the crank slide **114** as denoted by the point **192**. The crank mechanism illustrated in FIG. **7** (gear **80**, crank **118**, crank slide **114**) imparts sinusoidal motion to the bar folder assembly **40** as previously explained (also bar folder **42** and **44**). Thus, it can be seen, by following the sine wave velocity curve for the pivoting action of bar folder **40**, that the rod **108** is in the full up position when the crank slide is at 0°, at the bottom of crank **118** as shown in FIG. **7**. Thereafter, the rod **108** will be fully down to fold the outer panel **48R** when the crank slide **114** reaches 180° of a full revolution; the rod **108** will begin to rise as the crank slide returns to the 0° position after 360° of rotation of gear **80** as denoted by the point **194** at the intersection of the sine wave curve and the 360° line. It can also be seen the rod **108** is in the midposition of its upstream stroke, as denoted by point **192**, when it begins pivoting downward at the 0° beginning of rotation of the crank **118**. Rod **108** continues moving upstream until the crank **118** reaches 90° of its full rotation. Meanwhile, it can be seen that during this first 90° of rotation, the leading edge of blank **34** has passed beneath the rod **108** while the rod is still moving upstream; the blank continues to move downstream thereby resulting in more engagement of the rod **108** with the panel **48R** than if the rod moved downstream or was stationary at the time it first engaged the panel. As can be seen by following the dashed sine wave curve, the rod **108** begins moving downstream at the 90° point of rotation of crank **118**, just as it arrives at the midpoint of its pivotal downward movement, and moves in the same direction as the blank **34** while continuing to fold the panel **48R** downward against inner panel **60R**. However, the rod **108** begins pivoting upwardly at 180° while it is still moving downstream but begins moving upstream before it has pivoted to its full upward position at 360° of full rotation of crank **118** as illustrated by the sine wave curves. From the foregoing, it can be seen that the cycle of reciprocable movement lags the pivoting cycle by 90° resulting in maximum engagement of the bar **108** with the outer panel **48R** during folding. The bar folder assembly **42** operates in the same manner when it is selected to fold the outer panel **48L** first. Bar folder assembly **44** operates in a like manner, being spaced downstream the proper distance to engage the outer panel **48R** in the same manner as it is engaged by bar folder assembly **40** when the latter has been selected to fold outer panel **48R** first.

Preferably, the gear **80** (and corresponding gears for bar folders **42** and **44**) is timed with drive gear **74** so that the leading edge of the blank **34** just clears the end of rod **108** as it passes beneath it; thus, the blank will begin passing beneath the rod beginning at point **193** on FIG. **12** to permit the maximum amount of the outer panel to be engaged by the rod **108**.

One revolution of the crank **118** corresponds to the spacing between the leading edge of one blank to the leading edge of the blank following along the length of the belts **26L** and **26R**. This spacing results from the fact that the blanks are fed at timed intervals into the box machine in the well known manner. Thus, it can be seen that when blanks, shorter than the maximum length which can be fed into the box machine, are fed into the box machine, the spacing between the leading edges remains the same although there will be a gap between the trailing edge of one blank and the leading edge of the next. Since the bar folders **40**, **42**, and **44** are timed to the leading edges of the blanks, folding will occur at the proper time regardless of the length of the blanks.

As previously mentioned, one of the bar folder assemblies **40** and **42** is selected to make the first fold. When bar folder **40** is selected, bar folder **44** is inoperative; when bar folder **42** makes the first fold, bar folder **40** is inoperative. In either case, bar folder **42** remains operative, making either the first or second fold.

Selection of either bar folder **40** or **44** for operation is accomplished by connecting gear **76** or **84** to gears **80** or **88** (See FIG. **7**) by means of a selectively operable clutch assembly **150** as shown in FIG. **11**. By way of example, and as previously mentioned, gear **74** is connected to gear **80** through gear **76**. Gear **76** comprises one-half of clutch assembly **150**; a gear **152** (FIG. **11**) comprises the other half and is actually the gear that drives gear **80**. Gear **76** (as is gear **84**) is mounted for

rotation about a housing **154** by bearings **156**. The bearings **156** are secured to housing **154** by a threaded nut **158** on the end of housing **154** in the well known manner; this, in turn, retains gear **76** on the housing. Housing **154** is secured in a convenient manner to enclosure **72R**. A stub shaft **78** passes through housing **154** and has its opposite end supported by a housing **160** secured to lower rail **16R**. Gear **152** is supported for rotation about stub shaft **78** by bearings **162** and is held on the shaft by a threaded nut **164** in the well known manner.

Gear **152** includes a pair of diametrically opposed lugs **166** and **167** on the side face facing gear **76**. These lugs seat in matching recesses **168** and **169** formed in a protruding ring **171** on the adjacent face of gear **76**. These lugs form a single position clutch which will only engage in one place around the circumference of gear **76**. This is accomplished by making recess **168** larger than recess **169**; the matching lugs **166** and **167** are made to fit in the corresponding recesses as shown in FIG. **13**. This preserves the timing of gear **152** with respect to gear **76** and consequently the timing of the folding bar with respect to the drive train of the folder. While these lugs are in mesh, gear **76** drives gear **152** but when the lugs are moved out of engagement, the gear **76** will rotate but will not drive gear **152**. Gear **152** is moved out of engagement (as will be subsequently explained) with gear **80** to the dotted line position shown in FIG. **11**; at the same time, the lugs **166** and **168** are pulled out of engagement thereby preventing rotation of gear **80**, and consequently rotation of the slide block **118** to disable the bar folder assembly **40**.

FIGS. **7** and **8** illustrate the manner in which the bar folder assemblies **40** and **44** are selectively operated. Referring to FIG. **8**, a selector lever **170** is pivotally mounted by a pin **173** in a yoke **172** secured to a stub shaft **174**. Stub shaft **174** passes through enclosure **72R** and is anchored in a convenient manner to lower rail **16R** (connection not shown). Lever **170** is also pinned in a groove **176**, by pins **178**, in the ends of stub shafts **78**. The arrangement is such that when the lever **170** is pushed in on the left, as viewed in FIG. **8**, the stub shaft **78**, upon which gear **152** is mounted (See FIG. **11**), moves in toward lower rail **16R**, thus moving gear **152** our of mesh with gear **84** and simultaneously moving the other gear **152** into mesh with gear **80**; this, of course, disables the bar folder assembly **44**. Conversely, when lever **170** is pushed in on the right side, gear **152** is moved out of engagement with gear **76** and bar folder assembly **40** is disabled. In this manner, bar folder assemblies **40** and **44** are selectively operable.

The holddown bar assembly **46** includes a support bar **180** clamped (clamps not shown) between a pair of brackets **182** secured to lower rail **16L** as best illustrated in FIG. **10**. The holddown rod **184** itself is secured to a pair of support rods **186** which pass through the support bar **180**. The support rods **186** are preferably clamped (clamps not shown) in the support bar **180** so that the holddown rod **184** can be moved laterally a small amount to lie over the folded panel **48L** wherever desired. In addition, the support bar **180** is preferably pivotable in the brackets **182** so that the rod **184** may be raised or lowered to exert greater or lesser pressure against the folded panel **48L** as will be well understood by those skilled in the art.

The operation of the various elements of folder **10** has been described in connection with the description of the individual elements. Accordingly, no further description of operation of such elements is believed necessary. So far as overall operation is concerned, to fold the blanks **34** in the manner described, it is only necessary to position the flexible folding rods **36L** and **36R** to fold the outer panels **48L** and **48R** to a substantially upright position as previously described. Such settings depend somewhat on the proportions of the blanks being folded and are well understood by those skilled in the art. In addition, it must be determined which of the outer panels is to be folded first and the appropriate bar folder assembly **40** or **44** disabled as hereinbefore set forth. Thereafter, blanks **34** may be fed from the box machine (not shown) into the folder machine **10** where the outer panels **48L** and **48R** will be partially folded at first by the rods **36L** and **36R** and then finally folded by the folding bar assemblies **40** and **42** or **42** and **44**, depending on which outer panel is to be folded first. After folding, the blanks **36** are advanced out of the folder **10** for further processing.

As previously mentioned, several bar folder assemblies can be used in place of the flexible folding rods **36L** and **36R**. Such an arrangement is shown diagrammatically in FIG. **14**. In this arrangement, the bar folder assemblies **40**, **42**, and **44** and the hold-down bar assembly **46** remain as previously described. A number of additional bar folder assemblies **188**, **190**, **192**, and **194** are mounted upstream from the aforementioned assemblies as shown. These latter assemblies are essentially the same as the former in construction as will be described in connection with FIG. **15**. The main difference is that the bar folders **188** and **190** are arranged so that the rod portions **204** (denoted by the same numeral on all the additional assemblies) that contact the outer panels **48L** and **48R** begin by underlying the panels as the blank **34** enters the folder **10** in a flat, unfolded condition; the bar folders **188** and **190** are arranged to pivot upward to result in a fold angle of about 60°. These assemblies reciprocate in the direction of blank travel as previously described. In addition, they pivot simultaneously since, at this point, it is not necessary to fold one panel ahead of the other.

The next pair of bar folders **192** and **194** continue folding the panels upwardly from about 60° to about 120°, the same as the panels were folded by the flexible rods **36L** and **36R**. The principal advantage is that the bars **204** are parallel to the panels **48L** and **48R** during folding so that the panels are not twisted as they are folded.

The assemblies **188**, **190**, **192**, and **194** are driven by a cross shaft **208**. Cross shaft **208** extends between side frames **12L** and **12R** and passes through gear and crank assemblies (not shown) similar to assemblies **70L** and **70R**, which were previously described, and drive the associated bar folder assemblies in essentially the same manner. However, it should be understood that the clutch assembly shown in FIGS. **11** and **13** is not needed since the additional bar folder assemblies remain operative at all times. Cross shaft **208** may be driven by being connected to the aforementioned jackshaft (not shown).

As shown in FIG. **14**, it can be seen that bar folding assemblies **188**, **190**, **192**, and **194** are evenly spaced on either side of cross shaft **208**. This permits them to be connected to their associated crank slide **114** by pivot arms **228** (FIG. **15**) using the same gearing arrangement as decribed for bar folder assemblies **40**, **42**, and **44**. But, since bar folder assembly **194** is farther away from bar folder assembly **42**, because bar folder assembly **42** is downstream from bar folder assembly **40** for the reasons previously described, there is a gap between bar folder

assembly **194** and bar folder assembly **42**. The outer panel **48L** of the blank **34** must be held in its 120° fold angle position as it passes through this gap so that it will enter under rod **108** of bar folder assembly **42**. It is not desirable to extend the length of rod **204** on bar folder assembly **194** to span the gap since the bar folder assembly **194** will begin pivoting upward before the panel **48L** clears the rod **204**; this will permit the panel **48L** to spring upward so that it will not enter beneath rod **108** as it should.

Accordingly, the gap between bar folder assemblies **194** and **42** is filled with a hold-down bar assembly **200** similar in all respects to hold-down bar assembly **46** except that it is shorter as shown. Thus, it may be pivoted upward to a fold angle of about 120° corresponding to the fold angle of bar folder assembly **194**. In this manner, the outer panel **48L** is held at the proper fold angle to enter beneath the rod **108** of bar folder assembly **42**.

It can be seen that the bars **204** on bar folder assemblies **188** and **190** are not in longitudinal alignment with bars **204** on assemblies **192** and **194** and are not in longitudinal alignment with the bars **108** on the bar folder assemblies **40, 42,** and **44** as viewed in FIG. **14** which is a top view of the folder **10**. This may be more readily understood by referring to FIG. **15**. Since the bar folder assemblies **188** and **190** at the entrance end of folder **10** must be arranged so that the bars **204** underlie the panels **48L** and **48R**, it is necessary to mount the support bar **226** (equivalent to bar **100**, FIG. **9**) over the rail **16R** but beneath the outer panel **48R** so as not to interfere with advancement of the blank **34**. This also requires that the rail **16R** be lower relative to the height of conveyor **26R** as shown. It can also be seen that the shape of the pivot arm **228** must be different from the pivot arm **98** shown in FIG. **9**. The support **230** for the pivot arm **228** must also be shaped differently and link **120** must be longer to make the arm **228** pivot the desired distance. Otherwise, the assemblage of the parts is substantially the same as shown in FIG. **9** and the same part numbers are used in FIG. **15**. Since the folding rods **204** rise to different heights (e.g. 60° and 90°) because the folds are made in steps, it can be seen why the rods **204** are not in longitudinal alignment as shown in FIG. **14**.

Depending on the spacing between blanks, it may be necessary to include a hold-down bar assembly, similar to hold-down bar assembly **200**, between bar folder assemblies **188** and **192**, between bar folder assemblies **192** and **40**, and between bar folder assemblies **190** and **194** so that the advancing blanks **34** are held at the fold angle provided by the next upstream bar folder assembly for a time sufficient to permit the next downstream bar folder assembly to rise to its position for receiving the blank. It can also be seen that the length of the folder **10** would have to be increased to accommodate additional hold-down bar assemblies **200**.

Thus, the invention having been described in its best embodiment and mode of operation, that which is desired to be claimed by Letters Patent is:

1. Box blank folding apparatus comprising in combination:

advancing means for serially advancing box blanks continuously through said apparatus;

first folding means near an upstream end of said advancing means for folding outer panels of said box blanks to a substantially upright position as said blanks advance through said apparatus,

said first folding means comprising pivotable bar folder means near an upstream end of said advancing means and reciprocable in the direction of travel of said blanks for engaging substantial portions of said outer panels during the advance of said blanks through said apparatus; and

second folding means downstream from said first folding means for folding said outer panels from said upright position to a substantially horizontal position against inner panels of said blanks,

said second folding means comprising pivotable bar folder means reciprocable in the direction of travel of said blanks for engaging substantial portions of said outer panels during the advance of said box blanks through said apparatus.

2. Box blank folding apparatus comprising in combination:

first and second laterally spaced endless conveyor means for serially advancing box blanks continuously through said apparatus;

first and second upper rail means spaced above each of said conveyor means respectively and defining edges against which outer panels of said blanks may be folded to a substantially upright position;

first and second folding means underlying said outer panels near an upstream end of each of said conveyor means respectively and extending to a position overlying a top surface of said conveyor means for folding said outer panels from a horizontal position to said upright position as said blanks advance along said conveyor means;

a first bar folder means above said first conveyor means and downstream from said first folding means; and

a second bar folder means above said second conveyor means and downstream from said second folding means,

both of said bar folder means operable for folding said outer panels from said upright position to a substantially horizontal position over inner panels of said box blanks,

said bar folding means being pivotable from a substantially upright position adjacent said upright outer panels to a substantially horizontal position and being longitudinally reciprocable in an upstream direction during a first portion of pivotable movement of said bar folder means in a downward direction from said substantially upright position to said substantially horizontal position and being longitudinally reciprocable in a downstream direction during the remaining portion of pivotable movement of said bar folder means in said downward direction.

3. The apparatus of claim **2** wherein:

said first bar folder means is located upstream from said second bar folder means for folding one of said outer panels before the folding of the other of said panels by said second bar folder means.

4. The apparatus of claim **3** further including:

a third bar folder means downstream from said first bar folder means; and

selector means for selectively operating one of said first and third bar folder means,

to cause said first bar folder means to fold one of said outer panels before the folding of the other of said panels by said second bar folder means, and

to cause said third bar folder means to fold one of said outer panels after the folding of the other of said panels by said second bar folder means.

5. The apparatus of claim 4 wherein said selector means comprises:

lever means operatively connected to said first and third bar folder means for selectively connecting both of said first and said third bar folder means to a drive means for pivoting and reciprocating the selected one of said first and third bar folder means,

said first bar folder means, when selectively connected for operation, being operative to fold one of said panels before the other of said panels is folded by said second bar folder means, and

said third bar folder means, when selectively connected for operation, being operative to fold one of said panels after the other of said panels is folded by said second bar folder means.

6. The apparatus of claim 5 wherein said folding apparatus includes:

first and second laterally spaced lower rail means for supporting said first and second conveyor means respectively;

a drive shaft means extending laterally between said lower rail means;

a first gear means connecting said drive shaft means to said first bar folder means;

a second gear means connecting said drive shaft means to said second bar folder means; and

a third gear means connecting said drive shaft means to said third bar folder means,

said lever means adapted to engage a first clutch means in said first gear means for selectively connecting said first bar folder means for operation by said drive shaft means, and

said lever means adapted to engage a second clutch means in said third gear means for selectively connecting said third bar folder means for operation by said drive shaft means when said lever means is selectively positioned to disconnect said first bar folder means from operation by said drive shaft means.

7. The apparatus of claim 6 wherein said first gear means includes:

a first rotary crank means connected between said first gear means and said first bar folder means for pivoting said first bar folder means from said substantially upright position to said substantially horizontal position and back to said substantially upright position during each rotation of said first crank means and for reciprocating said first bar folder means from an upstream position to a downstream position and back to said upstream position during each rotation of said first crank means, downstream movement of said first bar folder means beginning after downward pivoting of said first bar folder means begins; and

a second rotary crank means connected between said third gear means and said third bar folder means for pivoting said third bar folder means from said substantially upright position to said substantially horizontal position and back to said substantially upright position during each rotation of said second crank means and for reciprocating said third bar folder means from an upstream position to a downstream position and back to said upstream position during each rotation of said second crank means, downstream movement of said third bar folder means beginning after downward pivoting of said third bar folder means begins,

said second crank means being inoperative during operation of said first crank means and said first crank means being inoperative during operation of said second crank means.

8. The apparatus of claim 7 further including:

a blank holddown means located downstream from said second bar folder means for holding said other of said outer panels in said horizontal position, after said other panel has been folded by said second bar folding means, during advancement of said blank along said conveyor means.

9. The apparatus of claim 8 wherein said first and second folding means comprise:

first and second flexible rod means; and

a plurality of adjustable support means mounting said rod means to said lower rail means.

10. Box blank folding apparatus comprising in combination:

first and second laterally spaced endless conveyor means for advancing box blanks through said apparatus;

first and second laterally spaced lower rail means for supporting said first and second conveyor means respectively;

first and second upper rail means spaced above each of said conveyor means respectively and defining edges against which outer panels of said blanks may be folded to a substantially upright position;

first and second flexible rod means underlying said outer panels near an upstream end of said conveyor means respectively and extending to a position above a top surface of said conveyor means for folding said outer panels from a horizontal position to said upright position as said blanks advance along said conveyor means;

a first bar folder means downstream from said first rod means and pivotable from an upright position adjacent a first of said outer panels to a horizontal position for folding said first panel over a first inner panel of said box blank;

a second bar folder means downstream from said second rod means and pivotable from an upright position adjacent a second of said outer panels to a horizontal position for folding said second panel over a second inner panel of said box blank after folding of said first outer panel;

a third bar folder means downstream from said first bar folder means and pivotable from an upright position adjacent said first outer panel to a horizontal position for folding said first panel over said first inner panel after folding of said second outer panel;

drive shaft means extending laterally between said lower rail means;

first, second, and third gear means connecting said drive shaft means to said first, second, and third bar folder means respectively,

said gear means being operative to pivot said first, second, and third bar folder means and to longitudinally reciprocate each of said bar folder means in the direction of travel of said blanks so that said bar folder means moves with said blanks during at least a portion of said longitudinal reciprocation; and

selector means for selectively operating said first and third gear means and consequently said first and third bar folder means connected thereto to cause said first outer panel to be folded ahead of or after folding of said second outer panel.

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